as a separate branch, diverging from the common stem of the genus Gentiana, even before *G. lutea*. For whilst in all other species of Gentiana the honey is secreted by an annular swelling of the base of the pistil, in this group the nectaries are situated at the base of the corolla itself, between the filaments (*n*, Figs. 101, 105). As hitherto *G. tenella* and *G. nana* have been distinguished only by somewhat fluctuating characteristics, it may be of especial interest that in *G. tenella* I have found each interstice between two filaments to contain two nectaries (*n*, Fig. 101), in *G. nana* only a single one (*n*, Fig. 105).

To the same group belong *G. campestris*, *germanica*, *amarella*, and *obtusifolia*, two of which have been directly observed by myself to be visited both by Lepidoptera and butterflies. For instance, near Pontresina and in the Val del Fain, August 6-8, 1876, I saw *G. campestris* repeatedly visited by *Bombus mendax*, Gerst. ☿, but also by butterflies (*Argynnis pales*, *Hesperia serratulæ*, *Colias phicomone*, *Lycæna argus*).

The fourth group of Alpine species of Gentiana exclusively adapted to cross-fertilisation by Lepidoptera, will be treated of in my next article.

Lippstadt HERMANN MÜLLER

(*To be continued.*)

DEEP SEA MUDS[1]

DURING the present session I propose to lay before the Society several papers on subjects connected with the deposits which were found at the bottom of the oceans and seas visited by H.M.S. *Challenger* in the years 1872, 1873, 1874, 1875, and 1876.

Instruments in use for obtaining information of the deposits.

It will be convenient to introduce this first communication with a brief description of the instruments and methods employed on board H.M.S. *Challenger* with the view of obtaining information and specimens of these ocean deposits. The instrument in most frequent use was the tube or cylinder forming part of the sounding apparatus.

During the first six months of the cruise this cylinder was one having less than an inch bore, and was so arranged with respect to the weights or sinkers that it projected about six inches beneath them. The lower end of the cylinder was fitted with a common butterfly valve. This arrangement gave us a very small sample of the bottom.

In July, 1873, this small cylinder was replaced by one having a two-inch bore, and it was also made to project fully eighteen inches below the weights. This was a great improvement, as it gave a much greater quantity of the bottom in most soundings.

The tube was, in the clays, frequently forced nearly two feet into the bottom. On its return to the ship, the butterfly valves were removed, and a roll of the clay or mud, sometimes eighteen inches in length, could be forced from it. In this way we learned that the deeper layers were very frequently different from those occupying the surface.

In the organic oozes—as the Globigerina, Pteropod, Radiolarian, and Diatom oozes—the tube did not usually penetrate the bottom over six or seven inches, these deposits offering more resistance than the clays and muds. Occasionally the tube came up without anything in it, but the outside was marked with streaks of the black oxide of manganese. In about thirteen out of nearly four hundred soundings we did not get any information of a reliable nature about the deposit.

The dredge in use was a heavy modification of Ball's naturalist's dredge, and the trawl was the ordinary beam trawl of the fishermen.

Both of these instruments had generally a bag of canvas or other coarse cloth sewed into the bottom of the netting, to prevent the soft clay or ooze from being entirely washed out. In this way we, at many stations, got, along with animals, a large quantity of ooze, clay, stones, or manganese nodules.

While trawling or dredging the ship often shifted her position a mile or two, but we could not tell whether the dredge or trawl had been working over all that distance, or had merely taken a dip into the deposits. This should be remembered when comparing the captures in one locality with those of another.

Altogether there is much uncertainty about the behaviour of the trawl and dredge in deep water. It occasionally happened that when the greatest care was taken, and when it was believed that the trawl had been dragging for some hours, it came up without anything in it, or any evidence upon it or in the attached tow-nets to show that it had been on the bottom.

During the last year of the cruise a tow-net was attached to the dredging line just below the weights, which last were placed a few hundred fathoms in front of the trawl or dredge. Tow-nets were also attached to the trawl and dredge. These nets frequently came up nearly full of mud, and almost always contained minute things and fragments from the surface layers of the bottom.

At times the water-bottle attached to the sounding line came up with clay or ooze in it, or had some of the deposit adhering to its under-surface.

These then were the means and methods employed for getting information concerning ocean deposits, and collectively they have furnished us with a large amount of material. A careful examination of the specimens procured has already much increased our knowledge of the nature and distribution of ocean deposits, of the sources of the materials of which they are built up, and of the chemical processes taking place in the deep waters and on the floor of the ocean.

The Volcanic débris in Ocean Deposits and some of the Products of its Disintegration and Decomposition.

In a preliminary report to Prof. Wyville Thomson, which has been published in the *Proceedings* of the Royal Society of London, I pointed out the wide-spread distribution of volcanic *débris* in ocean deposits, and its probable influence in the formation of deep sea clays, and manganese nodules or depositions. In this paper I propose to treat of these subjects in more detail, and to give some of the results of observations which have been made since the above report was written.

Pumice-Stones.

The form of volcanic *débris* most frequently met with in ocean deposits is pumice stone.

Specimens of these stones, varying from the size of a pea to that of a foot-ball, have been taken in dredging at eighty of our stations. I have placed the position of these stations on a map, from which it will be seen that they occur all along our route.

Near volcanic centres the dredge has frequently brought them up in great numbers, as off the Azores in the Atlantic, off New Zealand and the Kermadec Islands, at several places among the Philippine Islands, off the coast of Japan, and elsewhere. As a rule, they are not numerous in shore deposits when these are distant from volcanic regions. In deposits far from land they are most abundant in deep sea clays, from which the shells and skeletons of surface organisms have been all or nearly all removed.

In the North Pacific the trawl brought up bushels of them from depths of 2,300 and 2,900 fathoms. Perhaps in no single instance have we trawled successfully on any of our deep sea clays without getting numbers of these stones. If there be an exception it is in the North Atlantic. But here it is to be remembered that while we were investigating the conditions of the North Atlantic, our attention had not yet been directed to the importance of detecting the presence of pumice, and we have not preserved such large samples of the North Atlantic deposits as those of other regions.

On the whole, pumice-stones are more numerous in the Pacific than in the Atlantic deposits.

In the Globigerina and other organic oozes, they are abundant or otherwise, according as the deposit is near or far removed from volcanoes. In these oozes they never occur so abundantly as in the clays. They are more or less masked and covered up by the accumulated remains of foraminifera, diatoms, or other surface organisms. In like manner they are obscured in shore deposits by river and coast detritus. Besides those specimens, which are sufficiently large to be examined by the hand, we detected with the microscope minute particles of feldspar in all our ocean deposits.

An inspection of the specimens which I have placed on the table will show that the majority of these pumice stones have a rolled appearance. Some of them have undergone much decomposition, while others are little altered. Some are coated with the peroxide of manganese, or have streaks of this substance running through them. They are the most frequent nucleus of the manganese nodules, to which I shall presently refer. Some specimens which were dredged from a depth of over three miles, will, when dried, float for weeks in a basin of water; others, which have undergone partial decomposition, sink at once.

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[1] "On the Distribution of Volcanic Débris over the Floor of the Ocean; its Character, Source, and some of the Products of its Disintegration and Decomposition," by Mr. John Murray. Read at the Royal Society, Edinburgh.

They present a great variety of texture and composition. They are white, grey, green, or black in colour. They are highly vesicular, or rather compact and fibrous. There would appear to be every gradation from common feldspathic to dark green pyroxenic kinds.

We find in them crystals of sanidin, augite, hornblende, olivine, quartz, lucite, magnetite, and titaniferous iron. Magnetic iron ore was found in all the specimens examined, either in crystals or in the form of dust. The other minerals vary in kind and abundance in the different specimens. The same crystals which we find in the pumice occur in all the kinds of ocean deposits.

Sources of the Pumice-Stones.

The pumice-stones which we find at the bottom of the sea have most likely all been formed in the air. Some of them may have fallen upon the sea; but the great majority seem to have fallen on land, and been subsequently washed and floated out to sea by rains and rivers. After floating about for a longer or shorter time they have become water-logged and have sunk to the bottom. Both in the North Atlantic and Pacific small pieces of pumice were several times taken on the surface of the ocean by means of the tow-net. Over the surface of some of these serpulæ and algæ were growing, and crystals of sanidin projected, or were imbedded in the feldspar. During our visit to Ascension there was a very heavy fall of rain, such as had not been experienced by the inhabitants for many years. For several days after many pieces of scoriæ, cinders, and the like were noticed floating about on the surface of the sea near the island. Such fragments may be transported to great distances by currents.

On the shores of Bermuda, where the rock is composed of blown calcareous sand, we picked up fragments of travelled volcanic rocks. The same observation was made by General Nelson at the Bahamas. Mr. Darwin noticed pieces of pumice on the shore of Patagonia, and Prof. L. Agassiz and his companions noticed them on the reefs of Brazil. During a recent eruption in Iceland, the ferry of a river is said to have been blocked for several days by the large quantity of pumice floating down the river and out to sea. All the pumice which we find need not be of quite recent origin. Mr. Bates informs me that great quantities of pumice are continually being floated down the Amazon. These come from near the foot of the Andes, where the head-waters cut their way through fields of pumice-stones. In the province of Wellington, New Zealand, two of the rivers run through areas covered with pumice, and during floods bear great quantities out to sea.

Prof. Alex. Agassiz has kindly furnished me with the following note:—

"The river Chile, which flows through Arequipa, Peru, has cut its way for some thirty miles through the extensive deposits of volcanic ashes which form the base of the extinct volcano, Misti. Some of the gorges are even 500 feet in depth, forming regular cañons. The whole length of the river bottom is covered by well-rolled pieces of pumice from the size of a walnut to that of a man's head. In the dry season (winter) there is but little water flowing, but in the summer, or rainy season, the river, which has a very considerable fall (7,000 feet in a distance of about ninety miles), drives down annually a large mass of these rolled pumice-stones to the Pacific. The volcanic ashes are not recent. There is no tradition among the Indians of any eruption within historic times."

Capt. Evans, the present hydrographer to the navy, informs me that he frequently picked up pumice on the Great Barrier Reef of Australia.

Volcanic Ashes.

Near volcanic centres, and sometimes at great distances from land, we find much volcanic matter in a very fine state of division at the bottom of the sea. This consists of minute particles of feldspar, hornblende, augite, olivine, magnetite, and other volcanic minerals. In the South Pacific, many hundred miles from land, and from a depth of 2,300 fathoms, the trawl brought up a number of pieces of tufa entirely composed of these comminuted fragments. These particles appear to me to have been carried to the areas, where we find them, by winds, in the form of what is known as volcanic dust or ashes. Sir Rawson Rawson sent to Sir Wyville Thomson a packet of the volcanic ashes which fell on the island of Barbadoes, after an eruption in 1812 on the island of St. Vincent, W.I., one hundred and sixty miles distant. I have examined this, and find it made up of fragments of the same character as those in the tufa to which I have just referred, some of the particles being perhaps a little larger. We have sometimes found this ash in considerable abundance mixed up with the shells in a globigerina ooze. In the deposits for hundreds of miles about the Sandwich Islands there are many fragments of pyroxenic lava, which I believe have been borne by the winds, either as ashes, or in the form of Pele's hair.

At Honolulu we were informed that threads of Pele's hair were picked up in the gardens there after an eruption of Kilauea, one hundred and eighty miles from the volcano. This Pele's hair bears along with it small crystals of olivine.

Obsidian and Lava Fragments.

Small pieces of obsidian and of feldspathic and basaltic lavas were frequently found in deposits near volcanic islands.

At two stations in the South Pacific, many hundred miles from land, we dredged pieces of this nature of considerable size larger than ordinary marbles. It is difficult to account for the transference of these fragments to the places where they were found. It is, however, in this region, and this alone, that it may be necessary to bring in a submarine eruption to account for the condition of things at the bottom.

A consideration of these observations, and the specimens which are laid on the table, will, I think, justify the conclusion that volcanic materials, either in the form of pumice-stones, ashes, or other fragments, are universally distributed in ocean deposits.

They have been found abundantly or otherwise in our dredgings, according as these have been near or far from volcanoes, or as there has been much or little river and coast detritus, or few or many remains of surface organisms in the deposits.

Some of the Products of the Decomposition of Volcanic Débris.

Clay.—Pure clay, as is well known, is a product of the decomposition of feldspar, and the clay which we find in ocean deposits appears to have had a similar origin.

In the deposits far from land the greater part of the clay originates, I believe, from the decomposition of the feldspar of fragmental volcanic material, which we have seen to be so universally distributed.

Pumice-stone is largely made up of feldspar, and from its areolar structure is peculiarly liable to decomposition. Being permeated by sea-water holding carbonic acid in solution, a part of the silica and the alkalies are carried away, water is taken up, and a hydrated silicate of alumina or clay results.

Like most clays our ocean clays contain many impurities, these last being as varied as the sources whence the materials of the deposits are derived.

Let us briefly enumerate the sources of these materials.

We have (1) the matters derived from the wear of coasts, and those brought to the sea by rivers, either in a state of suspension or solution. The material in suspension appears to be almost entirely deposited within two hundred miles of the land.

Where great rivers enter the sea, and where we have strong currents, as in the North Atlantic, some of the fine detritus may be carried to a greater distance, but its amount can never be very large. In oceans affected with floating ice we have land *débris* carried to a greater distance than above stated; for instance, we can detect such materials in the deposits of the North Atlantic as far south as the 40th parallel N., and in the South Pacific as far north as the 40th parallel S.

Some of the substances in solution, as carbonate of lime and silica, are extracted by animals and plants to form their shells and skeletons; these last, falling to the bottom, form a globigerina, a pteropod, a radiolarian, or a diatom ooze. We have also the bones of mammals and fish mixed up in different kinds of deposits. These, as well as animal and vegetable tissues, generally are a source of phosphates, fluorides, some oxides of iron, and possibly of other inorganic material.

Sir Wyville Thomson, early in the cruise, suggested that much of the inorganic material in deposits is derived from the source to which I have just alluded. Our subsequent observations have, I think, shown that originally Sir Wyville gave too much importance to this as a source of the materials in our deep deposits.

2. We have the dust of deserts, which is carried great distances by the winds, and which, falling upon the ocean, sinks to the bottom and adds to the depositions taking place. In the trade-wind regions of the North Atlantic we have a very red-coloured clay, in deep water, which is largely made up of dust from the Sahara. Such dust frequently falls in this region as what is called blood-rain.

3. We have the loose volcanic materials, which have been shown to be universally distributed as floating pumice, or as ashes carried by the wind.

This short review shows that the clay in shore deposits is chiefly derived from river and coast detritus. As we pass beyond about one hundred and fifty miles from the shores of a continent the character of the clayey matter changes. It loses its usual blue colour, and becomes reddish or brown, and particles of mica and rounded pieces of quartz give place to pumice, crystals of sanidin, augite, olivine, &c. All this goes, I think, to show that in deposits far from land the clay is chiefly derived from volcanic *débris*, though in the region of the North Atlantic trade-winds much of it may be derived from the feldspar in the dust of the Sahara.

The pumice which floats about on the surface of the sea must be continually weathering, and the clay which results and the crystals which it contains will fall to the bottom, mingling with the deposit which is in course of formation. In our purest globigerina ooze this clay and these crystals are present. If a few of the shells, say thirty foraminifera, are taken from such a deposit, and carefully washed, and then dissolved away with weak acid, a residue remains, which is red-brown or grey in colour, according to the region from which the ooze came. If the same number of shells be collected from the surface and dissolved away in the same manner, no perceptible residue is observed. The clayey matter would therefore seem to have infiltrated into the shells soon after they fell to the bottom.

I have already mentioned several instances of pumice-stones having been found on coral-reefs. Many more instances could be given. These stones, undergoing disintegration in these positions, add clay, crystals of augite, hornblende, magnetic iron ore, &c., to the limestones which the coral animals are building up.

I have found these crystals in the limestones and red earth of Bermuda, and in a specimen of the limestone from Jamaica.

This observation, it appears to me, points out that the red earth of Bermuda, Bahamas, Jamaica, and some other limestones, may originally have been largely derived from fragmental volcanic materials, which were carried to the limestone while yet in the course of formation. There are also small particles of the peroxide of manganese in the red earth of Bermuda.

(*To be continued.*)

CHEMISTRY AND TELEGRAPHY[1]

DISCLAIMING at the outset any pretensions which could be advanced in his behalf for the honour conferred upon him, Prof. Abel assumed that his advancement to the position of president was intended more as a recognition of the special importance of chemical science in its application to telegraphy. Proceeding upon this assumption he made chemical science the basis of his address, and went on to show the principal directions in which it bears importantly upon the work of the telegraph engineer.

No stronger evidence of the value attaching to a combination of chemical with electrical research need be sought for than that which is to be found in the labours of the late Dr. Matthiessen. His investigations into the causes of the differences in the resistance of various kinds of commercial copper were followed by most important results.

The series of experiments so carefully conducted by him showed the influence which the principal metalloids and metals known to be naturally associated with copper exerted upon the conducting power of the pure metal, and he afterwards determined the conducting power of important varieties of commercial copper, and thus rendered it possible to assign to their real causes the enormous differences in the value of various kinds of commercial copper as conductors of electricity. For instance, amongst the many facts established by Matthiessen's experiments was the important one that by no combination of any other metal or alloy was it possible to increase the conducting power of pure copper, but that, on the contrary, a most prejudicial effect was exerted upon it by the presence of some of the non-metallic elements—notably oxygen and arsenic—which are almost invariably to be found as impurities in the copper of commerce. It was these non-metallic impurities he found rather than the presence of any of the other metals which chiefly impaired the conductivity of copper, although both iron and tin exercised a deleterious influence. Thus, fixing the conductivity of pure galvano-plastic copper at 100, the addition of merely traces of arsenic reduced it to 60; while an addition of 5 per cent. brought it as low as 6·5; the existence, again, of 1·3 per cent. of tin in pure copper reduced its conductivity to 50·4, and with only 0·48 per cent. of iron present the conductivity fell to 36.

Specially interesting were the experiments made by Matthiessen to ascertain the cause of the good effects which had long before his day been observed to be produced upon the working qualities of refined copper by the addition of minute quantities of lead. The existence of 0·25 per cent. of lead in copper renders it so rotten that it cannot be drawn into wire; the presence of even so minute a trace as 0·1 per cent. unfits it for wire-drawing. Some special action must therefore take place during the melting of copper which would serve to account for the toughening and softening effects obtained by the addition of a small quantity of lead. The fact that the copper when subjected afterwards to a most careful analysis shows nothing but the merest traces of lead, would indicate that during the process of melting, the lead combines with and removes from the copper some impurity which would otherwise materially affect its toughness and ductility. The well-known affinity of lead for oxygen, combined with the fact that the presence of oxygen in copper beyond some narrow limit was known to affect its quality prejudicially, afforded good reasons for supposing that this impurity could be nothing else than oxygen, and this view, which was further supported by the beneficial influence of lead when employed in casting operations with copper and gun metal, received the strongest confirmation of its correctness from Matthiessen's experiments. Thus, the addition of 0·1 per cent. of lead to a sample of copper (the two being fused together in a current of carbonic acid), raised its conductivity from 87·25 to 93, and the amount of lead remaining in the metal after that was too minute to be detected. So with tin, the alloying of 1·3 per cent. of which with copper reduced, as has been already stated, its conductivity to 50·4; yet on melting the sample fused in contact with air with 0·1 per cent. of tin raised its conductivity to 94·55.

It was these investigations of Matthiessen which indicated to the wire manufacturer whence he could obtain or how best fulfil the conditions for the purity of a quality of copper, which would meet the requirements of a conductor whose size might be laid down by the telegraph engineer, whilst his researches into the preparation of alloys brought the most valuable aid to the B.A. Committee of 1861, in their determination of the standards of electrical resistance.

But it is not only in facilitating the selection of suitable materials for *conductors*, as well as in raising their quality as such that chemical science has brought important aid to the telegraph engineer; it has been most usefully applied in the investigation and determination of the materials most suitable as the *dielectrics* of telegraph cables, and it is in this direction that telegraphy may look in the future for the most valuable results from the labours of the chemist. Dr. Miller's investigations (instituted at the desire of the Submarine Telegraph Committee) into the causes of the decay of gutta-percha and india-rubber, confirmed the results which Hoffman had already communicated in 1860 to the Chemical Society and which Mr. Spiller had obtained some years afterwards. But Miller examines more in detail than either of his predecessors has done, into the changes which these gums undergo, and firmly established the fact that the alterations in their structure, resulting in the gradual destruction of their insulating powers, was due entirely to atmospheric influence, accelerated by the exposure of the material to light. He further pointed out that intermittent exposure to moisture, especially if solar light has access, rapidly destroys gutta-percha, whilst if kept continually immersed in water it remains unchanged for an indefinite period. He also showed that commercial gutta-percha contained, previous to any special exposure to oxidising influences, as much as 15 per cent. of resinous matter and a considerable amount of water (2·5 per cent.) mechanically diffused through it. Considerable improvements had doubtless been made since that date in the mechanical processes for preparing gutta-percha, but these

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[1] Abstract of Address at the opening meeting of the Society of Telegraph Engineers, January 24, by the President, Prof. Abel, F.R.S.